Virginia City Hybrid Energy Center
Response to Data Request
Bruce Buckheit, Member, Virginia Air Pollution Control Board

Question (Page No. 18):

Low CO is a measure of good combustion and is used to evaluate the completeness of the combustion of organic hazardous air pollutants within the boiler. While CO emissions might not be of particularized and direct concern as a criteria pollutant, in the MACT process CO emissions are used as a surrogate for emissions of ethyl benzene, xylene, benzene, hexane, formaldehyde and polycyclic organic matter. Please perform an analysis of any CO impacts and perform a top down CO BACT analysis if the most effective control strategy for organic HAPs is not employed

Response:

A modeling analysis was conducted to assess all criteria pollutants as well as hazardous air pollutants (HAPs) and the facility demonstrated compliance with all air quality standards. The impacts of the CO emissions from VCHEC as compared to the National Ambient Air Quality Standards (NAAQS) are as follows:

Pollutant	Averaging Period	Maximum Concentration ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)	Percent of the NAAQS
CO	1-Hour	956	40,000	2.39%
CO	8-Hour	264	10,000	2.64%

As shown in the table above, the facility's CO impacts are less than 3% of the CO NAAQS. A BACT analysis was performed for the VCHEC and is included in the June 2006 and August 2007 air permit applications. BACT analyses in both applications determine that CO BACT for CFB boilers is good combustion practices. A review of EPA's RACT/BACT/LAER Clearinghouse reveals that all CFB's in the database use good combustion practices for CO as well as VOC control. Dominion is unaware of any CFB that implements CO or VOC (or organic HAP) controls other than good combustion practices. The catalysts below are not specific to the oxidation of CO and would be the same catalysts used for destruction of organic HAPs. The top-down CO BACT (which is also relevant to the organic HAP controls) analysis submitted with the air permit application is as follows:

5.2.3 Carbon Monoxide Emissions

Carbon monoxide emissions from the CFB boilers will be controlled by good combustion practices capable of achieving an emission level of 0.15 lb/MMBtu on a 30-day rolling average above 75% load or 0.20 lb/MMBtu on a 30-day rolling at 75% or less (excluding startup, shutdown, and malfunction periods).

5.2.3.1 CO Formation and Control

Carbon monoxide is a product of incomplete combustion in any combustor. The formation of CO is controlled by providing adequate fuel residence time, excess oxygen, and high temperature in the combustion zone to ensure complete combustion. The CO emissions from CFB boilers are somewhat higher than those from pulverized coal boilers. These higher CO emissions are a result of the lower combustion temperatures found in CFB boilers, thereby resulting in slightly less complete combustion. Still, good combustion is achieved in the CFB boilers by ensuring good air-fuel mixing, uniform bed temperatures, long residence time, and good combustion control. It should be noted that, although lower combustion temperatures may slightly increase CO emissions, they also minimize NO_x formation and promote higher SO_2 collection in the CFB boiler.

5.2.3.2 Recent BACT Determinations

A review of EPA's RBLC and recently issued permits identified the CO performance levels that may be achieved with various combinations of control technologies. The control technologies and associated performance levels for CFB boilers are listed in Table 5-1. As shown in this table, several new CFB boilers have received permits within the last five years that impose CO emission limits ranging from 0.10 to 0.27 lb/MMBtu. However, those CFB units required to meet a NO_x emissions limit of 0.07 lb/MMBtu typically need only meet a CO emission limit of 0.15 lb/MMBtu or higher. This reflects the need to optimize combustion conditions to control both NO_x and CO emissions from CFB boilers. The Project proposes to employ good combustion practices to achieve a CO emission level of 0.15 lb/MMBtu, consistent with the CO emission limits established for units required to meet the most stringent NO_x emission limit of 0.07 lb/MMBtu. Discussed below are the most stringent performance levels imposed on recently permitted CFB boilers that fire waste coal or bituminous coal.

In Pennsylvania, Wellington Development received a PSD permit last year for a waste coal-fired CFB boiler with an allowable CO emission rate of 0.20 lb/MMBtu as a 1-hour daily maximum. The Robinson Power Company received a PSD permit earlier last year for a waste coal-fired CFB boiler with an allowable CO emission rate of 0.15 lb/MMBtu as a 1-hour daily maximum. In 2003, Reliant Energy's Seward Power Plant received a PSD permit for a waste coal-fired CFB boiler with an allowable NO_x emission rate of 0.15 lb/MMBtu as a 3-hour average. In Kentucky, the East Kentucky Power Company received PSD permits for two CFB boilers burning waste coal at the Spurlock Generating Station with allowable CO emission rates of 0.15 lb/MMBtu on a 30-day rolling average. In Louisiana, Cleco Power received a permit with an allowable CO emission rate of 0.10 lb/MMBtu on a 30-day average at full load, and 0.15 lb/MMBtu on a 30-day average at part load (75% load or less). The Cleco permit includes a 12-month period when the allowable CO emission rate is 0.15 lb/MMBtu on a 30-day average. In West Virginia, the Western Greenbrier plant received a final PSD permit in 2006 for a CFB boiler firing waste coal with an allowable CO emission rate of 0.20 lb/MMBtu on a 24-hour average.

5.2.3.3 Alternative CO Control Technologies

The alternative CO control technologies available for coal-fired boilers are combustion controls and oxidation catalyst systems. These alternative CO control technologies are evaluated below in terms of their application to CFB boilers fired with waste coal.

Oxidation Catalyst

Oxidation catalysts have been applied to fossil fuel combustion sources, such as combustion turbines fired with natural gas of low-sulfur fuel oil. This technology, however, has never been applied to coal-fired boilers. It is evaluated here to determine if it could be considered transferable technology for application to the proposed CFB boilers. In an oxidation catalyst system, the flue gas passes over a catalyst to lower the activation energy required to convert products of incomplete combustion (*i.e.*, CO and VOC) in the presence of oxygen, to carbon dioxide and water. The catalyst permits oxidation of the reactant species at lower gas temperatures and residence times than would be required for uncatalyzed oxidation.

The catalyst would have to be located at a point where the gas temperature is within an acceptable range. The effective temperature range for CO oxidation is between 600 °F and about 1,000 °F. Catalyst non-selectivity is a problem for sulfur containing fuels such as coal. Catalysts promote oxidation of SO_2 to SO_3, as well as CO to CO_2. The amount of SO_2 conversion is a function of temperature and catalyst design. Under optimum conditions, formation of SO_3 can be minimized to 5% of inlet SO_2. This level of conversion would result in a collateral increase in H_2SO_4 emissions, which could result in unacceptable amounts of corrosion to the fabric filter baghouse, air preheater, ductwork, and stack.

Oxidation catalysts are known to be extremely sensitive to potential masking, blinding or poisoning due to trace metals in the flue gas. While natural gas or fuel oil contains essentially no trace metals, coal contains many of such trace metals within the inert fraction referred to as fly ash. Trace metal concentrations are highly variable even from coal taken within the same mine or seam. There is no empirical evidence available to show that oxidation catalyst technology would actually work with coal-fired boilers or, if so, how the trace metals would ultimately affect the life of the catalyst. Due to the high particulate loading, variable trace element concentrations, and high SO_2 concentrations, oxidation catalyst systems are considered technically infeasible for application to the proposed CFB boilers.

Combustion Controls

Combustion control refers to controlling emissions of CO through the design and operation of the boiler in a manner so as to limit CO formation. In general, a combustion control system seeks to maintain the proper conditions to ensure complete combustion through one or more of the following operation design features: providing sufficient excess air, staged combustion to complete burn out of products of incomplete combustion, sufficient residence time, and good mixing. All of these factors also tend to reduce emissions of VOC, as well as CO. The use of waste coal with a high percentage of fines, complicates the tuning of these factors due to the variability expected in the waste fuel. In addition, this process must be optimized with the efforts to reduce NO_x emissions, which may increase when steps are taken to lower CO are taken.

5.2.3.4 Conclusions

Based on a review of available control technologies for CO emissions from CFB boilers, we conclude that the lowest sustainable CO emission rate that has been demonstrated in practice and can be guaranteed for the proposed CFB boilers burning bituminous coal is 0.15 lb/MMBtu on a 30-day rolling average above 75% load or 0.20 lb/MMBtu on a 30-day rolling at 75% or less (excluding startup, shutdown, and malfunction periods). The only practical means of achieving this CO emission level is good combustion practices, which must not only minimize the formation of CO, but also limit the formation of NO_x. Given the need to optimize NO_x and CO emissions, a CO emission rate of 0.15 lb/MMBtu on a 30-day rolling average represents BACT for the proposed CFB boilers. No cost analysis is necessary because the top feasible technology is selected.